Final Report Joint Fire Sciences Program AFP 2004-2

Project Title: Effects of 40 years of prescribed fire on pine regeneration and productivity.

Project Number: 04-2-1-35

Project Location: Santee Experimental Forest, Cordesville, South Carolina.

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This final report summarizes the findings to-date, provides a reconciliation of the planned accomplishments, and presents the status and planned follow-up activities.

SUMMARY OF FINDINGS TO DATE

Background

The Santee Fire Plot is among the oldest ongoing prescribed fire studies in the United States. The study was established in 1946 to test the effects of fire frequency and seasonality on pine growth, vegetation, and soil properties. The treatments comprised a factorial of periodic and annual, summer and winter burns. After 42 years of burning there were no deleterious effects of the treatments, through the consideration of tree growth and soil nutrients. In 1989, the treatment stands were destroyed by hurricane Hugo, and a new stands was regenerated in the original treatment plots boundary. The plots have not been burned since 1989.

Observations of the plots ten years after being regenerated suggested that there was a legacy of the prescribed fire treatment on the regenerated stand. The current study was posed to determine whether the regenerated stand shows an effect from the legacy of fire treatments. Specifically, this project considered a detailed assessment of the vegetation community, tree productivity and soil biogeochemistry in an attempt to address this critically important question. The project also provides the benchmark for continuing the fire treatments, now that the stand is of sufficient stature.

Communication and technology transfer were a major objective of the work associated with this study. Those accomplishments are presented in Table 1, which cross-walks the intended activities with the actual accomplishments. The outreach and communication accomplishments exceeded the planned activities.

Regeneration Response to 40 years of Prescribed Fire

Vegetative Community

The vegetative community, 11 years following regeneration, has retained the general characteristics of the stands after 40+ years of burning history. Prior to regeneration, the annual fire plots were a park-like stand of a pine overstory and grasses and sedges in the

understory. Presently, the plots still contain the highest number of species and the community is dominated by grasses and sedges. Interesting, there is very little hardwood invasion, and it consists primarily of *Liquidambar styraciflua* which is regenerating from seed. In contrast, the annual winter burn plots have a shrub and sub-canopy layer that is dominated by *Liquidambar styraciflua,* and they're virtually devoid of the grasses that are found in the annual-summer burn plots. *Liquidambar styraciflua* is also prominent in the undrstory on the control plots, but not to the same extent as the winter-burn plots, and other hardwoods are also a minor component (e.g., *Acer rubrum*, *Nyssa sylvatica*). *Myrica cerifera* was a component of all the plots, regardless of fire history; its presence maybe important because it is host for symbiotic nitrogen fixation. Unfortunately, the sampling design didn't include biomass partitioning; it appeared as though the biomass was larger on the winter-burn and control treatments.

The species-coverage data confirmed that the community attributes can be sustained through the regeneration phase and into mid-rotation stand development. The implications from these data are important for realizing a sustainable prescribed fire prescription. In the southeastern US where the development of a pine savannah is desired, fire is prescribed on 3-5 year cycle to control hardwood vegetation. Earlier studies on these plots and elsewhere have shown that a 3-5 year burn cycle does not eradicate the hardwood competition, instead the actual numbers of stems increases, but stature is constrained by the periodic dieback as a result of the fire. In contrast, with the frequent (i.e., annual) summer burn the hardwoods are eliminated from the stand in 7-9 years, and that effect is persistent into mid-rotation on the second generation stand. In an operational context, frequent burning for a few years to control hardwoods may enhance capacity for prescriptions because once controlled, the stands could endure periods (>8 years) between fire intervals without undue concern about competing vegetation dominating the site.

Pine Productivity

Pine growth was the metric used to assess whether fire frequency and season had an adverse affect on site productivity in the first phase of this experiment (thru 1989). The original treatments were imposed on a stand that was approximately 40 years old, hence when the stands were destroyed in the hurricane, they were approximately 82 years old. The growth assessments at that time documented that there wasn't a difference in pine (*Pinus taeda*) growth as a result of the treatments.

Measurements of the height development on the regenerated (natural + planted) loblolly pine (*Pinus taeda*) showed that control > periodic winter / summer > annual winter / summer after 10 years. That relationship was evident after the first 3 years of growth, and has remained consistent. The largest difference is among the control versus fire treatments, approximately 6 ft; the differences among fire treatments in 4-5 feet after 10 years. The average tree DBH and stocking was also greater on the control relative to the fire treatments.

The productivity measures confirm the premise that the trees on the control plot are larger and growing a more rapid rate than those regenerated with a 40-year fire history. At this stage of stand development, the difference is not too large, however, one could expect

those differences to magnify during the next 5-10 years as the stands approach physiological maturity. It should also be noted that the regardless of treatment, the stands were fully stocked, with respect to overstory trees.

Soil Properties

The studies on soil properties conducted during the first phase of the study (thru 1989) concluded that there wasn't a difference in soil nutrients among treatments, although there was some re-translocation within the soil profile. We used the same sampling approaches to assess soil nutrient pools 10 years after the stands had been regenerated.

There are differences evident in the soil nutrients among plots with a prescribed fire history as compared to the control plots (i.e., unburned). Specifically, the levels on nitrogen, calcium and potassium are considerably less in the annual burn treatments as compared to the control. Interesting, the differences among the annual summer and annual winter treatments are small and varied. Similarly, there were few differences among the periodic burn treatments and the control. Where differences exist among treatments, it was usually manifest in the surface soil.

The level of extractable soil nutrients among treatments is arrayed similarly to the growth (height) response, suggesting a functional linkage.

Perspectives and Planned Follow-up

This study has shown that the legacy of prescribed fire is manifest in the regenerated stand, in terms of community composition and stand conditions. Despite the absence of prescribed fire for 12 years after regeneration, the stands that had the desired pine-savannah vegetation prior to regeneration, retained those properties, and the addition of fire would ensure that condition into the future. Despite the earlier reports, there is a difference in soil nutrient capital; this difference may either be an artifact of the treatments and regeneration phase (e.g., a cumulative effect from the control) or it may be effect of the burn treatment; further work will be needed to assess the specific cause(s).

Most of the public lands that are managed with frequent prescribed fire prescriptions have an objective of wildlife habitat, diversity of vegetative communities, or recreation; hence maintaining a high level of productivity is not central to realizing the management objective. The observed differences in productivity may either be interpreted as the control plots having been stimulated as a result of the regeneration treatment or that there has been some degree of impairment on the fire treatments. At this stage, the cause is not clear and additional work will be needed. Ongoing analyses of the data may also yield additional insight, and hence guide considerations for future work.

This study provides a unique opportunity for education and future research. The cumulative effects of this these treatments on regeneration are not available through other studies; hence we plan to continue to use the plots as a demonstration site. The plots also have considerable potential to consider the under laying causes of the cumulative effects, as this work has documented that they exist. Those avenues of investigation should include the nitrogen cycle, especially the contributions of through symbiotic fixation,

organic matter turnover, and assessments of nutrient uptake and NPP. The study also affords the opportunity to assess the species-level adaptability and inter-species competition during stand development. Finally, these data will also be used in considering if further treatments should be imposed on these plots or whether they cumulative effects should continue to observed un-complicated by contemporary treatments.

Table 1. Crosswalk between proposed and delivered communication activities as stated the project proposal, 2004.

Proposed	Delivered	Status
Workshop (1)	- Presented findings to National Forest Management Team April, 2006 - Presented study and findings at the national meeting of Regional Soil Scientists; June, 2006.	Completed
Field Workshop (1)	- Francis Marion National Forest Resource Staff (October, 2005) - Regional Soil Scientist meeting, June, 2006. - IUFRO – Silviculture Working Group Conference. (September, 2006).	Completed
Management Presentation (1)	- Hosted meeting for the Francis Marion and Sumter National Forest. November, 2005, Charleston, SC - Francis Marion resource staff briefing, April 2006. Columbia, SC	Completed
Web site	- Project web site developed through the Unit's home page (www.srs.fs.fed.us/charleston).	Completed
General Technical Report (1)	- A GTR presenting a synthesis of fire effects on the coastal plain has been developed and published. (The Effects of Prescribed Fire and Thinning on Vegetation, Fuels, Erosion, and Nutrients in the Coastal Plain and Piedmont. L. Fairchild and C.C. Trettin. General Tech. Rept., Southern Res. Station, Asheville, NC. Jan 07)	Completed
Fact Sheet (1)	- Two fact sheets were developed and used in the workshops and field briefings.	Completed
Field signage for tours	- Signage was installed (2005) demarking the experimental track and treatment plots.	Completed
Manuscript (1)	- The manuscript presenting the findings from this study is being finalized and will be submitted spring or summer, 2007.	Ongoing